



Chemical Management Guide

For The Laboratory

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INTRODUCTION

Dave Waddell, of the Local Hazardous Waste Management Program in King County, Washington, a member of the Technical Assistance and Pollution Prevention Team has graciously agreed to allow the State of Iowa to reproduce or adapt large portions of this management guide (the 4th edition) to help Iowa citizens manage hazardous materials.

The first edition of this management guide, published in 1994, was prepared by representatives from several groups: the King County Water and Land Resources Division, the Local Hazardous Waste Management Program in King County, the Northwest Laboratory Coalition, and the Washington Biotechnology Association. Baz Stevens from King County's Industrial Waste Section (formerly the Municipality of Metropolitan Seattle) was one of the original authors.

The management guide will help reduce the amount of hazardous waste generated by schools or businesses and the metals or chemical contaminants improperly disposed into waters, sewers, and landfills. The practices recommended in this guide will help analytical, medical, teaching, and biotechnology labs properly manage hazardous materials and reduce hazardous waste.

**For a full copy of the report with specific Iowa
information visit our Web site**

www.iowadnr.com

For additional help, see the contacts listed in the "For More
Information" section of this report.

CHEMICAL STORAGE

Laboratories generally use a variety of toxic, corrosive, reactive and flammable materials. If these are stored close together or in fragile containers, there is a risk of vapor mixing breakage and spills that release harmful, toxic materials into the environment. Proper storage of chemicals requires the use of prudent handling and storing practices and a well-constructed lab facility.

Components of a Safe and Effective Chemical Storage Area

- Maintain an inventory of chemicals stored in each lab.
- Anchor hazardous material storage cabinets to walls.
- Close and latch doors on storage cabinets.
- Provide separate corrosion-free cabinets for flammable liquids, concentrated inorganic acids and caustic liquid bases.
- Keep a Class ABC fire extinguisher near locations where chemicals are stored or used and train employees in its operation.
- Provide secondary containment for stored chemicals.
- Keep chemicals secure and safe to prevent unauthorized use.

Storing and Handling Chemicals

- Store incompatible materials separately. Refer to the *Incompatible Chemicals* section below for further information on safe chemical storage.
- Properly label containers with the name of the compound, date of arrival and its primary hazards. Chemical symbols alone are insufficient identification.
- Regularly check expiration dates on chemicals. Dispose of them or use them promptly and properly.
- Write the date received on each chemical container that arrives and the date opened on all containers of peroxidizable compounds and materials.
- Reduce the risk of bottle breakage. Whenever possible, order concentrated acids and flammable solvents in plastic-coated bottles. Small containers are more durable and less likely to break than large ones. Use rubber or plastic bottle carriers or bottle jackets when transporting glass containers.
- Keep containers closed when not in use so contents cannot evaporate or escape a tipped container.
- Return chemicals to their proper place after use or at least before leaving the work station at the end of the day.
- Avoid storing chemicals in fume hoods. They interfere with the air flow, clutter work space and could potentially spill into cup sink drains.
- Avoid storing chemicals on bench tops.
- Properly store or dispose of all hazardous materials before leaving the workstation.
- Avoid storing chemicals under sinks.
- Store flammable liquids in “lab-safe” equipment with external thermostats, manual defrosting, etc., designed specifically for flammable chemicals.

SYSTEMATIC STORAGE OF LAB CHEMICALS

We suggest following the storage and handling guidelines found in *Prudent Practices in the Laboratory* by the National Research Council’s Committee on Hazardous Substances in the Laboratory (National Academy Press, Washington, DC, 1995).

Many universities publish diagrams of their chemical storage system on their Web sites. These are often based on the storage system published in the National Research Council’s *Prudent Practices in the Laboratory*.

Two chemical supply companies, J.T. Baker and Flinn Scientific Inc., also have popular systems for chemical storage that incorporate the concept of “related and compatible storage groups” found in *Prudent Practices*. These systems are based on a series of codes for functional classes of chemicals. Organic and inorganic chemicals are separated, with sub-groups further separated. The “related and functional storage groups listed in *Prudent Practices*” and the shelf storage codes often assigned to these groups are listed below. (“I” refers to inorganic compounds and “O” refers to organic compounds.)

- O-1** Organic acids, anhydrides, peracids
- O-2** Alcohols, glycols, amines, amides, imines, imides
- O-3** Hydrocarbons, esters, aldehydes
- O-4** Amines, imines, pyridine
- O-5** Ethers, ketones, ketenes, halogenated hydrocarbons, ethylene oxide
- O-6** Epoxy compounds, isocyanates
- O-7** Organic peroxides, hydroperoxides, azides
- O-8** Sulfides, polysulfides, sulfoxides, nitriles
- O-9** Phenols, cresols

- I-1** Metals, hydrides
- I-2** Halides, sulfates, sulfites, thiosulfates, phosphates, halogens
- I-3** Amides, nitrates (except ammonium nitrate), nitrites, azides
- I-4** Hydroxides, oxides, silicates, carbonates, carbon
- I-5** Sulfides, selenides, phosphides, carbides, nitrides
- I-6** Chlorates, perchlorates, chlorites, hypochlorites, peroxides
- I-7** Arsenates, cyanides, cyanates
- I-8** Borates, chromates, manganates, permanganates
- I-9** Inorganic acids
- I-10** Sulfur, phosphorus, arsenic, phosphorus pentoxide

- Flammable liquids must be stored in flammable storage cabinets or fire safety cans.
- Alphabetical storage is discouraged except within compatible groups.
- Most guidelines have adapted this list to create a systematic shelf storage system.

Unfortunately, this system is confusing to implement. For example, many of the listed chemicals are hazardous liquids that should be stored in specialized cabinets rather than on shelves. For labs with restricted storage spaces, compatible storage can be provided by grouping chemicals with similar hazards together. These labs could use a simplified system like the one illustrated in Table 1.

TABLE 1
Shelf Storage Pattern for Small Stockrooms

Organic Shelves	O-1	Dry and dilute organic acids, anhydrides, peracids
	O-5 & O-7	Organic peroxides, azides
	O-6 & O-8	Epoxy compounds, isocyanates, sulfides, sulfoxides, nitriles
	O-9	Miscellaneous organics: Powdered and alcohol-free stains and indicators
Inorganic Shelves	I-1 & I-10	Sulfur, phosphorus, arsenic, metals, hydrides (store away from water!)
	I-2	Halides, sulfates, sulfites, thiosulfates, phosphates, halogens
	I-3, I-6 & I-8	Nitrates, nitrites, borates, chromates, manganates, permanganates, chlorates, chlorites,inorganic peroxides
	I-4	Dry hydroxides, oxides, silicates, carbonates
	I-5 & I-7	Sulfides, selenides, phosphides, carbides, nitrides, arsenates, cyanides
Flammable Storage Cabinet	O-2, O-3, O-4, O-9	Hydrocarbons, ethers, ketones, amines, halogenated hydrocarbons, aldehydes, alcohols, glycols, phenol, cresol, combustible organic acids, combustible anhydrides
Corrosive Acid Storage Cabinet	I-9	Inorganic acids. Nitric acid stored separately in this or another cabinet
Corrosive Base Storage Cabinet or Cupboard		Concentrated inorganic hydroxides

Notes: Keep water reactive metals away from aqueous solutions and alcohols. Use secondary containers to separate yellow and white phosphorus, which are stored under water, from water-reactive metals.

Flinn Scientific Inc. has a diagram in their catalog or online at www.flinnsci.com/Sections/Safety/labChemSafety.asp

PLANNING FOR RENOVATION AND NEW CONSTRUCTION

- Avoid putting chemical storage shelves or cabinets over sinks. Accidental spills or breakage could release chemicals to the sewer.
- If you install a house vacuum system, use dry-seal or non-contact water pumps. Pumps that use contact water may discharge chemicals to the sewer.
- If a safety shower discharges to a laboratory floor drain, construct the drain in an appropriately-sized sump with a standpipe to prevent spilled chemicals from going down the drain while allowing water from the shower to drain. Check your local building code to determine whether such sumps must be double-contained.
- If available, select a sink that has a lip to provide spill protection.
- Contact the local plumbing inspector early in the process to clearly communicate to them where acidic wastes could accidentally enter drains and where they could not. This could save time and costs from having to stop the process to replace cast-iron piping with acid resistant piping.
- Passive acid-treatment tanks are often recommended by architects in classrooms and laboratory spaces. For most situations, these systems are very difficult to manage and maintain. Sulfuric acid creates a “slime” layer in contact with limestone that requires physical agitation or high pressure rinsing to remove. Once the slime layer is in place, the limestone chips no longer neutralize acidic wastewaters. This could damage downstream side-sewer lines and lead to very expensive pavement-cutting and sewer repair projects.

Sargent-Welch has free resources for teachers and facility managers to use during design and construction.

CHEMICAL SPILL MANAGEMENT

Spill management plans are very dependent on the size and complexity of the facility and the diversity and comparative hazards of the chemicals being used in the lab. Excellent examples of spill management plans are available from many university's environmental health and safety program websites. A few key components should be part of every laboratory's spill response procedures:

- Major spills are typically identified as difficult and require immediate emergency response assistance. Major spills are difficult to contain, likely to harm personnel, or pose an immediate and serious fire risk.
- Prepare for major spills by working with your local emergency responders to develop a notification and evacuation plan. At some facilities, initial response to major spills may be by the facility's trained emergency response team. For many other labs, these spills are beyond the capacity of onsite staff.
- Minor spills typically can be cleaned up by laboratory staff or facility-based emergency response teams, however, only clean up minor spills when you know the chemical's name and hazards and have protective equipment and spill kits that can handle it. Proper labeling and spill response training is important for staff to learn before a spill happens.
- Spill response training should be carefully designed to distinguish between major and minor spills and between similar chemicals with different hazards. Many lab staff can easily clean up a spill of 500 milliliters of 25 percent sodium hydroxide solution. Few lab staff can safely clean up a similar spill of ammonium hydroxide. Both are corrosive bases, but ammonium hydroxide's intensely irritating vapors pose a unique hazard.
- Small labs, such as a high school science lab, should have simple, easy-to-use spill kits. The kit should contain citric acid for spills of liquid bases, sodium carbonate for acids, and granular absorbent for organic solvents. Sand is sometimes applied to increase traction in spills of slippery compounds like sulfuric acid and sodium hydroxide.
- Contact your local sewer agency to learn when they should be notified of a spill entering the sanitary sewer.

INCOMPATIBLE CHEMICALS

When they come in contact with each other, incompatible chemicals could react by releasing toxic or flammable gases, exploding or spontaneously igniting. Segregate and store chemicals by hazard class to minimize the risk of reactions between incompatible chemicals and label storage cabinets and cupboards with the hazard class of the stored materials. Material safety data sheets (MSDSs) must be available for all chemicals on site. MSDS sheets can be found online at www.ilpi.com/msds/

Review them for information about incompatibilities. The following is a partial list of common incompatible chemicals that can react with each other:

Acids and Bases

Store strong acids and bases separately in enclosures made of corrosion-resistant materials.

Oxidizing Chemicals

Oxidizers are materials that yield oxygen readily to stimulate the combustion of organic matter. When oxidizers come in contact with flammable solvents, they can start or fuel fires. Typical oxidizing agents found in laboratories include chromates and dichromates, halogens and halogenating agents, peroxides and organic peroxides, nitric acid and nitrates, chlorates and perchlorates, and permanganates and persulfates.

- Store oxidizers away from alkalis, azides, nitrites, organic compounds (including acetic acid), powdered metals and activated carbon.
- Avoid contact between oxidizers and common combustible materials such as paper, cloth and wood.

Water-Reactive Compounds

Water-reactive compounds include alkali earth metals such as lithium, potassium and sodium, sodium borohydride, calcium carbide and sodium peroxide. Solutions containing water, such as inorganic acids and alcohols, should be kept separated from these chemicals during storage and use.

- Store water-reactive compounds away from aqueous solutions, inorganic acids, base solutions and alcohols. Though many chemical storage systems recommend water reactive solids be stored in flammable storage cabinets, in many cases this would not be prudent since these cabinets often contain alcohols with 30 percent water.
- Keep a Class D fire extinguisher near storage and use areas for these compounds.
- Store these compounds in locations protected from automated sprinklers.
- Alkali metals should be stored in areas where they are free of moisture, contact with oxygen, and, in the case of lithium, nitrogen gas.
- Only the amount of water-reactive materials necessary to perform the work should be removed from storage. Spare materials should be returned to the appropriate storage container and the container to its appropriate location.
- Storage containers should be labeled with their contents, hazardous properties and type of oil or gas used to inert the metal. Furthermore, these containers should be stored individually or in a manner that allows visual inspection for container integrity.
- Storage areas should be free of combustibles and of ignition sources.
- The portions of the building dedicated as storage area for alkali metals should not be equipped with automatic sprinklers. No other source of water (e.g., showers, sinks) should be in the immediate proximity of the metal.
- Storage areas should be prominently labeled to indicate the presence of alkali metals.

POTENTIALLY EXPLOSIVE CHEMICALS

Several classes of chemicals may become explosive when they react with other compounds or may become unstable during storage. Seriously review and question whether you need these compounds in your facility. These include peroxidizable solvents, potentially explosive dinitro- and trinitro- organic compounds and elemental potassium. If you have spills of any of these chemicals contact the Iowa DNR Emergency Response & Homeland Security Unit, Environmental Hazardous Conditions for assistance.

DNR 24 hour Emergency Spill Response
Phone Number: (515) 281-8694

Metal Azides

Inorganic azide compounds, such as sodium azide, can react with metals and their salts to produce explosive metal azide crystals. For example, when azide solutions are poured down drains, the dilute solution can react with lead solder and copper pipes to produce explosive lead or copper azide salts.

- If you must use azide solutions, replace metal pipes with PVC or other non-metal piping materials.
- If sodium azide solutions have been discharged to drains having metallic pipes or solder, you should assume your pipes may be contaminated with metal azide salts.

Ethers and Other Peroxide-forming Chemicals

Certain ethers are more susceptible to peroxide formation than others. Peroxides are formed by oxygen that reacts with ethers: R-O-R is ether; R-O-O-R is peroxide. It is the oxygen-to oxygen bond that makes ether unstable (peroxidizes). Generally, the larger the alkyl group (R), the more readily the ether will form peroxides. Ethyl ether and isopropyl ether can react with air to form explosive peroxide crystals. Other solvents such as tetrahydrofuran and dioxane can also produce peroxides.

Peroxides can explode when subjected to heat, friction or shock. Do not disturb or open containers in which peroxides may have formed.

A good rule of thumb is to dispose of any container holding a peroxide-forming compound one year after the date it was opened. Disposal should be with a licensed Hazardous Waste Contractor, see page 17 for more information. Label these containers with the words “DATE OPENED” and add the date.

To prevent the formation of peroxides:

- Avoid using peroxide-forming solvents if possible.
- Purchase ether with butylhydroxy toluene (BHT) or ethanol added as an anti-oxidant, although the compound should still be treated as a peroxide forming material.
- Label ether containers with the dates they are opened.
- Purchase ether in containers small enough to use all the solvent within six months.
- Check the MSDS for your solvents to see if any are prone to creating peroxides.

Elemental potassium is a peroxide-former that is commonly used in school laboratories to demonstrate characteristics of period 1 earth metals. Potassium is a water-reactive earth metal that reacts with moisture in the air to start the peroxidation process. This process can be observed by physical changes in the color of the potassium sticks. Originally a dull silver color, potassium will oxidize and form white crystals on its surface. As these crystals progressively turn yellow, orange, red and purple, the peroxidation process is advancing and the compound is increasingly at risk of exploding when handled [Blair, 2000].

Elemental sodium metal is common in school laboratories. Sodium metal itself is both caustic and toxic, but much more problematic is the fact that elemental sodium spontaneously breaks down water into its component parts, hydrogen and oxygen, immediately upon contact. This reaction occurs so quickly and so violently that it produces a great quantity of heat, which more often than not ignites the highly flammable hydrogen gas, and that hydrogen gas then burns even more fiercely due to the presence of all that free oxygen. If a large enough quantity of sodium metal is involved, sufficient heat may be generated by these burning gases to reach a temperature where the sodium metal itself may then ignite. Alcohols react with elemental sodium to produce hydrogen gas and the sodium alkoxide: $2ROH + 2Na \rightarrow 2NaOR + H_2$. This reaction is a measure of alcohol acidity.

Metal Picrates and Picric Acid

Metal picrate compounds and picric acid can become dangerously unstable as a dry powder. Picric acid can dry out and form explosive picrate crystals when exposed to air, especially when contaminated with even minute amounts of metals. To prevent the formation of explosive picrate crystals:

- Always keep picric acid wet or in solution.
- Avoid contact between picric acid and metals. Metal picrate salts are prone to explode when subjected to friction or shock.
- Never purchase or store picric acid in containers with metal lids.
- Avoid flushing picric acid solutions down drains.
- Dispose of more concentrated picric acid solutions as hazardous waste.
- Bouin's Fixative contains picric acid and formaldehyde solution (formalin.) Be sure to keep this fixative hydrated with water. *Bouin's 2000 is a picric acid and formalin-free alternative available from American Master*Tech Scientific, Inc. 800-860-4073.*
- If picric acid solutions have been discharged to drains with metallic pipes or soldered joints, assume the piping is contaminated with explosive metal picrate salts.

Perchloric Acid

Perchloric acid is highly corrosive and typically occurs as a 70 percent solution. When warmed above 150 degrees Fahrenheit, it is a powerful oxidizer. Perchloric acid can form explosive metal perchlorate crystals in combination with heavy metals. Any work with perchloric acid must be done in a specially-designed fume hood with a water wash down system designed to prevent the buildup of metal perchlorates in the duct work. If you have been performing perchloric acid digestions in a fume hood not specifically designed for perchloric acid, contact the Iowa DNR's, Energy and Waste Management Bureau at (515) 281-4367 immediately for assistance in locating a contractor to evaluate the hood for perchlorate contamination.

Spills and other emergencies: In the event of a perchloric acid spill, neutralize with soda ash (sodium carbonate) or another appropriate neutralizing agent. Soak up the spill with an inorganic based absorbent. Do NOT use rags, paper towels, or sawdust and then put them aside to dry out, as such materials may spontaneously ignite. Likewise, spills on wood may present a fire hazard after the liquid dries.

- If you must use perchloric acid solutions, replace metal pipes with PVC or other nonmetal piping materials.
- If perchloric acid solutions have been discharged to drains having metallic pipes or solder, you should assume that your pipes may be contaminated with metal azide salts or metal perchlorates. **Contact your Hazardous Waste Company, or the Iowa DNR's, Energy and Waste Management Bureau at (515) 281-8694** for assistance in determining the proper disposal procedures.

Regularly inspect your containers of perchloric acid for discoloration. White crystals around the cap are typically an ammonium salt, and small amounts may be washed off the bottle to the sewer using large amounts of water, being sure to thoroughly flush the sink and pipes for at least 3 min with running water. If the acid has turned a dark color and has crystals forming around the bottom of the bottle, there is a potential explosion hazard. **Do not touch or move it, notify an emergency response agency immediately and secure the area.**

Ammoniacal Silver Staining Solutions

Ammoniacal silver staining solutions are hazardous because they can form explosive silver salts. Safe use of these staining solutions includes the following procedures:

- Don't allow silver nitrate to remain in ammonium solutions for more than 2 hours.
- Keep silver nitrate solutions separate from ammonium hydroxide solutions.
- Deactivate these waste solutions by diluting 15:1 with water. Then, while stirring frequently, slowly add 5 percent hydrochloric acid to the solution until the pH reaches 2.
- Add ice if the solution heats up.
- Silver chloride will precipitate out when the pH reaches 2.
- Filter out the precipitate and dispose as hazardous waste, adjust the pH of the solution to 6 to 7 with sodium bicarbonate, then discharge to the sanitary sewer.

Wastewater and Solid Waste Disposal Guidelines

All wastewater discharged to the sewer system must comply with local, state and federal standards. These are designed to protect surface waters and to maintain the quality of biosolids from wastewater treatment plants. Discharge to a septic tank system is regulated as if the discharge was directly to groundwater, so virtually no wastes may go to a septic tank.

Do not discharge laboratory wastes to a septic system. Laboratory operations often generate hazardous wastes that contain dilutions and mixtures of chemicals in very low concentrations or in small quantities. See Appendix A for Iowa guidelines for disposal of non hazardous wastes to the sewer system.

Solid waste guidelines are designed to protect local and regional landfills, transfer stations, their customers and their employees. Appendix B lists Iowa guidelines for solid waste disposal. In general, each component of a waste stream must meet all criteria listed in the relevant appendix to be accepted for disposal as a solid waste.

The guidelines in the appendices are offered as a starting point for proper sewer and solid waste disposal and should not be considered definitive. Many aspects of the hazardous waste regulations, (listed wastes, off-spec chemicals, mixtures, formulations, etc.), are not covered in Appendices A and B. Please refer to Federal Guidelines from the EPA 40 CFR 261.20 for waste designation procedures. The Federal regulations can be found at www.gpoaccess.gov/cfr/index.html and adding the regulation number you would like to review. The school has full responsibility for waste characterization and regulatory compliance. Certain wastes that fail the criteria listed in Appendix A may be suitable for discharge to the sewer under special rules. Under all conditions, obtain written authorization from your local Water Treatment Facility or a local sewer utility to discharge wastewater that falls outside these criteria.

**For information on solid waste disposal, contact the
Iowa DNR at 1-800-Iowa-DNR or visit
www.iowadnr.com/waste/index.html**

Again, these guidelines do not provide authorization to allow discharge of hazardous chemicals to the sewer. They serve, in part, as a guideline to assist Iowa schools in determining whether their waste may be acceptable for discharge to the sewer.

FOR MORE INFORMATION

Iowa Waste Exchange

IWE is a free service designed to help schools and businesses find markets for industrial by-products and surplus materials. The mission of the Iowa Waste Exchange is to provide Iowa industries with waste management alternatives and business assistance services that result in both economic and environmental benefits including waste diversion from Iowa landfills. Through IWE, schools and businesses with materials they can no longer use may be matched with others who may need the materials. Materials are advertised at no cost.

For materials management alternatives, contact the Iowa Waste Exchange (IWE) at www.recycleiowa.org/exchange.html or (515) 242-4906.

Hazardous Waste Management

The Department of Natural Resources (DNR) helps Iowa citizens, schools and communities create a cleaner environment and stronger economy through the sustainable use of natural resources. Effective waste management and pollution prevention are two proven strategies for meeting that goal.

For waste management assistance contact the DNR at (515) 281-5918 or visit www.iowadnr.com/waste/index.html. For information on Pollution Prevention call (515) 281-5353 or visit www.iowadnr.com/waste/p2/index.html.

Hazardous Waste Management—Regional / Local Options

Collection facilities are located throughout the state that assist local governments, schools, or citizens with Hazardous Waste Management. These facilities are called Regional Collection Centers (RCCs) and provide a convenient location for citizens to dispose of household hazardous waste.

For more information on your local RCC call (515) 281-5859 or for a map of locations visit www.iowadnr.com/waste/hhm/index.html.

Sewer Disposal Guidelines

For more information on State Wastewater guidelines contact the Iowa Department of Natural Resources at (515) 281-4736, or on the Web at www.iowadnr.com/water/index.html. For information on local sewer guidelines contact your local sewer utility or Wastewater Treatment Plant.

Air Quality Management

For more information on air quality guidelines in the State of Iowa, contact the Air Quality Bureau at (515) 242-5100 or www.iowadnr.com/air/index.html.

Health and Safety Programs

For more information on health and safety regulations contact the Division of Labor Services at www.iowaworkforce.org/labor/index.html. The Labor Services Division is responsible for many programs designed to protect the safety, health and economic security of all Iowans.

RESOURCES FOR REDUCING THE SCALE OF EXPERIMENTS AND ANALYSES

The National Microscale Chemistry Center offers workshops, seminars and publications on the operation and advantages of converting labs to the microscale level. Contact them via phone at (508) 837-5137 or at their website at www.microscale.orgsilvertech.com/microscale/.

The National Small-Scale Chemistry Center is located at Colorado State University with regional centers across the United States. The focus of small-scale chemistry is the teaching lab. It is currently in use at secondary schools, community colleges and universities. Small scale differs from microscale in its use of inexpensive plastic materials in place of traditional glass apparatus. Both the volumes and concentrations of chemicals are reduced with these substantial benefits:

- Lower costs of materials and chemical
- Increased safety from use of unbreakable plastic and nonhazardous solutions
- Reduced lab set-up and clean-up times, which allows more hands-on chemistry education. Visit their Web site at www.smallscalechemistry.colostate.edu/ for more information and a free video demonstrating the benefits of small-scale chemistry.

APPENDIX A

Iowa Guidelines for Sewer Disposal

Characteristic or Criteria	Acceptable to sewer if meets ALL of these criteria	Unacceptable to sewer if exhibits ANY of these criteria
Flash Point	>65 degrees C or 140 degrees F	<65 degrees C or 140 degrees F
Boiling Point	>65 degrees C or 140 degrees F	<65 degrees C or 140 degrees F
Corrosivity	5.5 to 12.0	<5.5 or >12.0
Solubility	Water Soluble	Water insoluble
Reactivity Water or air reactive; explosive	Non-reactive	Water or air reactive; explosive polymizer, Creates toxic gas or nuisance stench
Radioactivity	Meets IA Dept. of Health limitations ¹	Does not meet Dept. of Health limits ¹
Persistence	Halogenated organic compounds, <0.01% Polycyclic aromatic hyrdocarbons, <1.0% ² Carcinogen PAH compounds ³	Halogenated organic compounds >.0.01% PAH concentration >1.0%
Toxicity	Iowa Administrative Code 567.62 (455B) adopted by reference Federal 40 CFR Part 129	

Important Note: These guidelines for sewer disposal are not definitive. Many aspects of Iowa Administrative Code 567-62.1(455B) (e.g., listed wastes, off-spec chemicals, mixtures, formulations, etc.) could not be covered in this table. Please refer to Iowa Administrative Code 567-62.1(455B)for waste designation procedures.

These guidelines are offered as a starting point for proper sewer disposal. The discharger must take full responsibility for waste characterization and regulatory compliance. Under all conditions, obtain written authorization from the Iowa Water Quality Bureau to discharge wastewater that falls outside these criteria.

1. Iowa Administrative Code 641-40.72(136C)
2. Polynuclear aromatic hydrocarbons (PAH) include acenaphthene, acenaphthylene, fluorene, anthracene, fluoranthene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, pyrene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno (1,2,3-c,d)pyrene, benzo(g,h,i)perylene, naphthalene, and phenanthrene .
3. Carcinogen PAH compounds :benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysens, dibenzo(a,h,)anthracene, and indeno(1,2,3-cd) pyrene

Small quantity generators of hazardous waste should contact their sewer agency to see if they are partially exempt from the Toxic Mixtures discharge requirements.

APPENDIX B
State of Iowa Guidelines For
Solid Waste Disposal (IAC 567 Chapter 109)

Characteristic or Criteria Unacceptable for Solid Saste Disposal in Iowa

Physical State	Liquid
Corrosivity (pH)	≤2.0 or ≥12.5
Reactivity	Water or air reactive; expolosive; polymerizer. Creates Toxic gas or stench
Radioactivity	Does not meet Dept. of Public Health limits ¹
Toxicity Characteristic Leaching Procedure	Must be less than federal limits in 40 CFR Part 261
Polynuclear aromatic hydrocarbon (PAH) Carcinogens	Total PAH ² level may not exceed 1600 ppm for listed compounds or 220 ppm for listed carcinogen ³ compounds or 1000 ppm for cyanide
PCB	Cannot exceed 50 ppm

1. Iowa Administrative Code 641-40.70 (136C)
2. Polynuclear aromatic hydrocarbons (PAH) include acenaphthene, acenaphthylene, fluorene, anthracene, fluoranthene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, pyrene, chrysene, benzo(a)pyrene, dibenz(a,h)anthracene, indeno(1,2,3-c,d)pyrene, benzo(g,h,i)perylene, naphthalene, and phenanthrene .
3. Carcinogen PAH compounds :benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysens, dibenzo(a,h,)anthracene, and indeno(1,2,3-cd)pyrene

APPENDIX C
Excessive Risk Chemicals
Risk Exceeds Educational Utility

Chemical Name	Hazards
Acetic Anhydride	Explosive potential, corrosive
Acetyl Chloride	Corrosive, dangerous fire risk, reacts violently with water and alcohol
Acrylamide	Toxic by absorption, suspected carcinogen
Acrylonitrile	Flammable, poison
Adipoyl Chloride	Corrosive; absorbs through skin, lachrymator
Aluminum Chloride, anhydrous	Water reactive, corrosive
Ammonia, gas	Corrosive lachrymator
Ammonium Bifluoride	Reacts with water, forms hydrofluoric acid
Ammonium Bichromate	May explode on contact with organics, suspected carcinogen
Ammonium Chromate	Oxidizer, poison; may explode when heated
Ammonium Dichromate	Reactive, may cause fire and explosion
Ammonium Perchlorate	Explosive; highly reactive
Ammonium Sulfide	Poison, corrosive, reacts with water and acids
Aniline	Carcinogen, toxic, absorbs through skin
Aniline Hydrochloride	Poison
Antimony Oxide	Health and contact hazard
Antimony	Powder flammable as dust, health hazard
Antimony	Trichloride corrosive; emits hydrogen chloride gas if moist
Arsenic compounds	Poison, carcinogen
Asbestos	Friable inhalation health hazard, carcinogen
Azide Compounds	Explosive in contact with metals, extremely reactive, highly toxic
Barium Chromate	Poison
Benzene	Flammable, carcinogen
Benzoyl Peroxide	Organic peroxide, flammable, oxidizer
Beryllium and its compounds	Poison, carcinogen, dust is P-listed and highly toxic
Bromine	Corrosive, oxidizer, volatile liquid
Cadmium compounds	Toxic heavy metal, carcinogen
Calcium Fluoride	Emits toxic fumes when heated
(Fluorspar) Teratogen	
Carbon Disulfide	Flammable, toxic, P-listed and extremely hazardous
Carbon Tetrachloride	Toxic, carcinogen
Chloral Hydrate	Hypnotic drug, controlled substance
Chlorine	Poison gas, corrosive
Chlorobenzene	Explosive limits 1.8% to 9.6%, toxic inhalation and contact hazard

Excessive Risk Chemicals
Risk Exceeds Educational Utility

Chemical Name	Hazards
Chloroform Carcinogen	If old forms deadly phosgene gas
Chlorosulfonic Acid	Toxic a/k/a Sulfuric Chlorohydrin
Chromic Acid	Strong oxidizer, poison
Collodion	Flammable, explosive when dry nitrocellulose compound
Cuprous Cyanide	Toxic
Cyanogen Bromide	Poison, strong irritant to skin and eyes
Cyclohexene	Flammable, peroxide former
Dichlorobenzene	Toxic
Dichloroethane	Flammable, toxic
Dinitro Phenol	Explosive. “Bomb Squad”
Dinitrophenyl Hydrazine	Severe explosion and fire risk
Dioxane	Flammable, peroxide former
Ether, Anhydrous	Flammable, peroxide former
Ether, Ethyl	Flammable, peroxide former
Ether, Isopropyl	Flammable, peroxide former
Ethyl, Ether	Flammable, peroxide former
Ethylene Dichloride	Toxic, contact hazard, dangerous fire risk, explosive in air 6-16%
Ethyl Nitrate	Explosive. “Bomb Squad”
Ethyleneimine	Flammable, toxic, P-listed
Ferrous Sulfide	Spontaneously ignites with air if wet
Formaldehyde (Formalin)	Toxic, carcinogen, sensitizer
Gunpowder	Explosive
Hydrazine	Flammable, absorbs through skin, carcinogen, corrosive
Hydriodic Acid	Corrosive, toxic
Hydrobromic Acid	Corrosive, poison
Hydrofluoric Acid	Corrosive, poisonous
Hydrogen	Flammable
Hydrogen Sulfide, gas	Poison, stench
Immersion Oil (old)	May contain 10-30% PCBs such as Arochlor 1260
Isopropyl Ether	Flammable, highest-risk peroxide former
Lithium Aluminum Hydride	Flammable, reacts with air, water and organics
Lithium Metal	Reacts with water, nitrogen in air
Mercaptoethanol	Flammable, corrosive, intense stench
Mercury compounds	Poisonous heavy metal
Mercury, liquid	Toxic heavy metal, carcinogen
Methylene Chloride	Toxic, carcinogen, narcotic

Excessive Risk Chemicals
Risk Exceeds Educational Utility

Chemical Name	Hazards
Methyl Ethyl Ketone	Flammable, dangerous fire risk, toxic
Methyl Iodide (Iodomethane)	May be a narcotic, carcinogen, lachrymator.
Methyl Isocyanate	Flammable, dangerous fire risk, toxic
Methyl Isopropyl Ketone	Toxic
Methyl Methacrylate	Flammable, vapor causes explosive mix with air
Naphthylamine, a-	Combustible, toxic, carcinogen
Nickel Oxide	Flammable as dust, toxic, carcinogen
Nicotine Poison	P-Listed extremely hazardous
Nitilotriacetic Acid	Corrosive
Nitrobenzene	Highly toxic
Nitrocellulose	Flammable, explosive, call ETSI
Nitrogen Triiodide	Explosive. “Bomb Squad”
Nitroglycerin	Explosive. “Bomb Squad”
Osmium Tetraoxide, “Osmic Acid”	Highly toxic, P-listed extremely hazardous
Pentachlorophenol	Extremely toxic
Perchloric Acid	Powerful oxidizer, reactive
Phosphorus Pentasulfide	Water reactive, toxic, incompatible with air and moisture
Phosphorus Pentoxide	Oxidizer, toxic
Phosphorus, Red	Flammable solid
Phosphorus, Yellow or White	Air reactive, poison
Picric Acid, Trinitrophenol	Explosive when dry
Potassium Cyanide	Poison, P-listed extremely hazardous
Potassium Perchlorate	Powerful oxidizer, reactivity hazard
Potassium Sulfide	Flammable, may ignite spontaneously
Potassium, metal	Water reactive, peroxide former (orange fog/crystals)
Pyridine	Flammable, toxic, vapor forms explosive mix with air
Selenium	Toxic
Silver Oxide	Poison
Silver Cyanide	Extremely toxic
Sodium metal lump	Water reactive, ignites spontaneously in dry hot air, corrosive
Sodium Arsenate	Toxic, carcinogen
Sodium Arsenite	Toxic, carcinogen
Sodium Azide	Poison, explosive reaction with metals. P-listed extremely hazardous
Sodium Borohydride	Flammable solid, water reactive
Sodium Cyanide	Poison, P-listed extremely hazardous
Sodium Fluoride, (Bifluoride)	Highly toxic by ingestion or inhalation; strong skin irritation

Excessive Risk Chemicals
Risk Exceeds Educational Utility

Chemical Name	Hazards
Sodium Fluoroacetate “Tox-X”	Deadly poison!
Sodium Peroxide	Water reactive; may cause fire and explosion
Sodium Sulfide	Fire and explosion risk
Strontium	Flammable, store under naphtha, reacts with water
Testosterone HCl	Controlled substance
Tetrahydrofuran	Flammable, peroxide former
Thioacetamide T	Toxic, carcinogen, combustible.
Thionyl Chloride	Corrosive
Thiourea	Carcinogen
Titanium Trichloride	Flammable, fire risk.
Triethylamine	Flammable, toxic, irritant.
Trinitrobenzene	Explosive. “Bomb Squad”
Trinitrophenol	Explosive. “Bomb Squad”
Trinitrotoluene	Explosive. “Bomb Squad”
Uranium/Uranyl Compounds	Radioactive

HIGH RISK CHEMICALS
Only Allow Very Limited Amounts in Storage
Only Appropriate for Advanced-Level High-School Science Classes

Chemical Name	Hazards
Acetamide	Carcinogen, P-listed extremely hazardous
Ammonium Nitrate	Powerful oxidizer, reactive
Barium Peroxide	Fire and explosion risk with organic materials, oxidizer, toxic
Butyric Acid	Corrosive, intense stench
Cadmium sulfide	Highly toxic, carcinogen
Calcium Carbide	Flammable, reaction with water
Chromium Trioxide	Oxidizer, poison
Ethidium Bromide	Potent mutagen
Hexamethylenediamine	Corrosive, absorbs through skin, lachrymator
Hexanediamine, 1-6	Corrosive, absorbs through skin, lachrymator
Hydrogen Peroxide, >29%	Powerful oxidizer, corrosive to skin
Lead compounds	Highly toxic
Lead Nitrate	Toxic heavy metal, oxidizer
Magnesium, powder	Flammable
Mercury Thermometers	Toxic heavy metal, corrosive
Phenol	Poison
Potassium Chlorate	Powerful oxidizer, reactive
Potassium Chromate	Oxidizer, toxic
Potassium Dichromate	Powerful oxidizer, carcinogen
Radioactive Materials	Radioactive
Sebacoyl Chloride	Corrosive fumes, lachrymator
Silver compounds	Toxic
Sodium Chlorate	Powerful oxidizer
Sodium Chromate	Oxidizer
Sodium Dichromate	Reactive, may cause fire and explosion
Sodium, metal, in small chips	Water reactive, corrosive
Strontium Nitrate	Oxidizer, may explode when heated or shocked
Thermite	Flammable solid
Toluene	Flammable, dangerous fire risk, toxic
Wood’s Metal	Poison
Xylene	Flammable, toxic

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